Radiative Flux Anomalies from 2000 to 2008 based on Combined CERES and FLASHFlux Data

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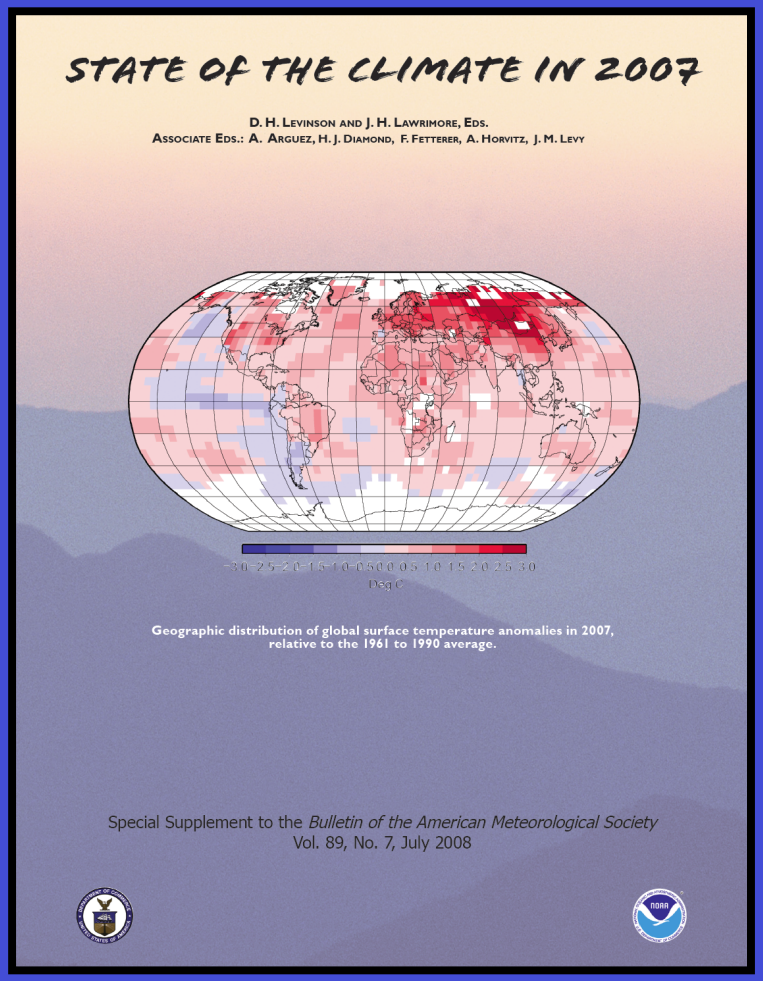
Motivation



- We were invited by NOAA/NCDC last November to participate in their special annual BAMS report on the "State of the Climate in 2008", which will appear in the July 2009 issue.
- NOAA wants to expand the coverage this year to include, for the first time, a section on Global Earth Radiation Budget.
- We agree to take on this challenge and that has lead us to examine the CERES instrument record from 2000 to 2008.

Objective

- Examine the changes in global mean TOA radiation fields from 2000 to 2008, with emphasis on 2008 change, using combined CERES (EBAF and ERBE-like; 3/2000 to 8/2007) and FLASHFlux (7/2006 to 12/1008) data product
  - Focus on global mean
  - Technique for merging these datasets into an unified time series
  - Examine consistency between datasets and uncertainty of the merging process
  - Show preliminary changes in 2008; relative to both the long term (2000 to 2008) climatology and to 2007
  - Outline future work for improving these preliminary results

TOA Radiation Datasets

CERES Terra EBAF Edition1A 3/2000 to 10/2005 → Most accurate using new CERES algorithms (updated in-orbit calibration, new CERES ADM, MODIS scene ID, best diurnal cycle using GEO data, ..) with global net radiation anchored to ocean heat storage value

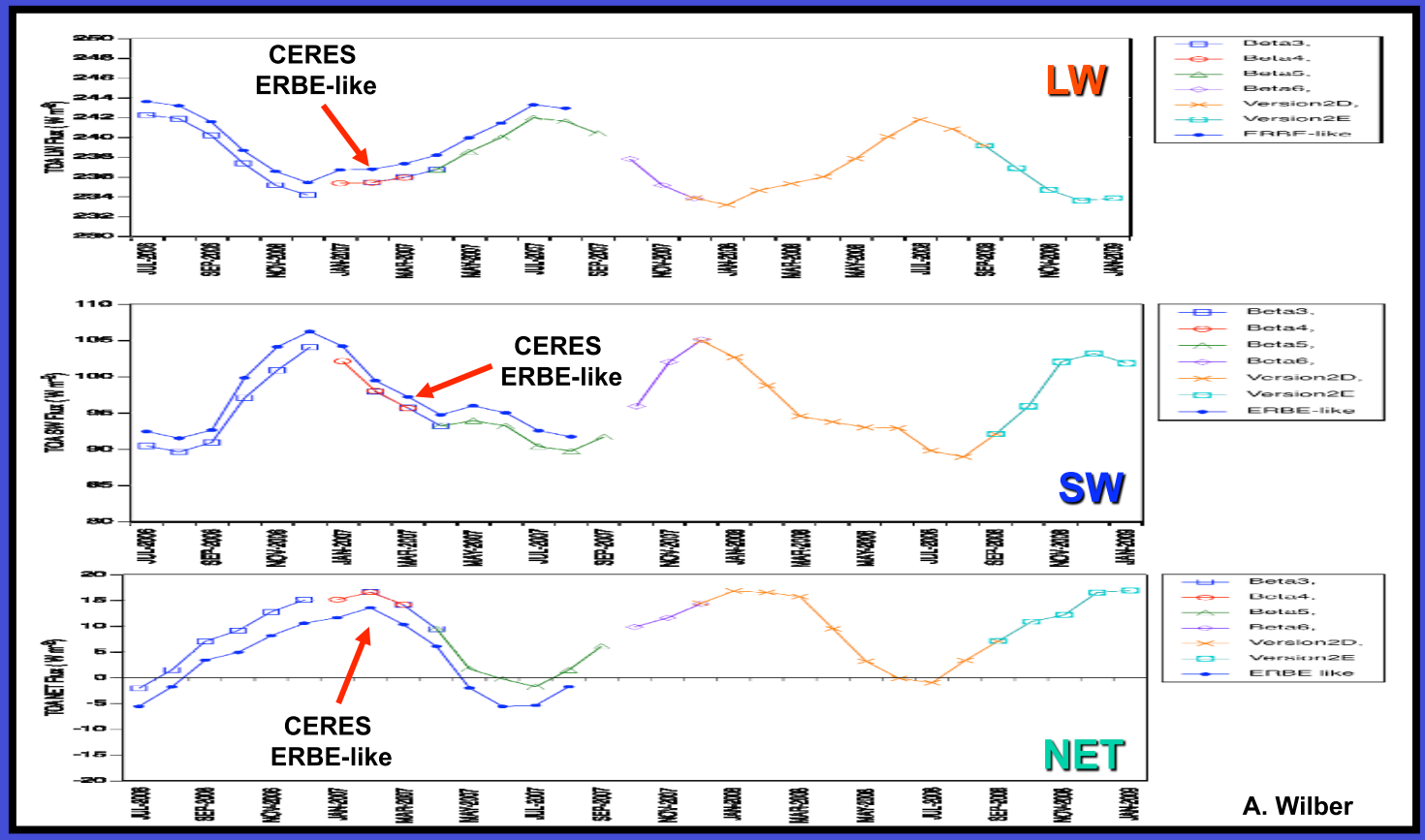
CERES Terra ERBE-like ES4 Edition2_Rev1 1/2003 to 8/2007 → Not as accurate as EBAF, but highly stable, using old ERBE algorithms (updated in-orbit calibration, ERBE ADM, ERBE scene ID, ERBE constant meteorology, ..)

FLASHFlux Terra+Aqua 7/2006 to 12/2008 → May contain calibration drift; based on new CERES algorithms (new CERES ADM, MODIS scene ID, enhanced diurnal cycle with Terra + Aqua data, ..) with constant calibration coefficients from last known CERES values

Fast Longwave and Shortwave Radiative Fluxes (FLASHFlux) from CERES and MODIS

- FLASHFlux lead: Paul Stackhouse and Dave Kratz
- Fill the community need for a quick release earth radiation budget dataset due to the long latency of the current CERES products (6 to 24 months)
- The long CERES latency is needed for careful instrument study to produce a stable long term climate data record.
- FLASHFlux is less accurate than the CERES products due to the use of constant calibration coefficients from the last known CERES values.
- This is a scientific compromise in order for a quick release of the FLASHFlux data product.
- FLASHFlux instantaneous and time-averaged data are usually available within one week of CERES and MODIS measurements.

CERES ERBE-like and FLASHFlux Data



- CERES ERBE-like and FLASHFlux global means track each other very well during the overlapped period

Data Merging Process

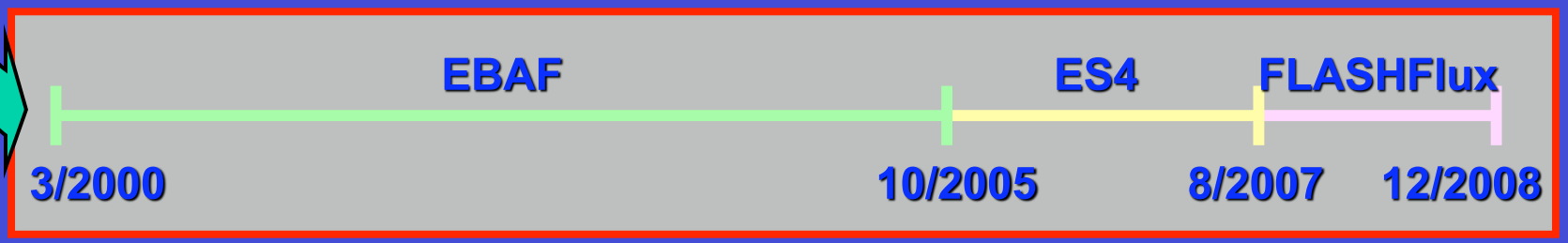
CERES Terra
EBAF
Edition1A
3/2000 to 10/2005

CERES Terra
ERBE-like ES4
Edition2_Rev1
1/2003 to 8/2007

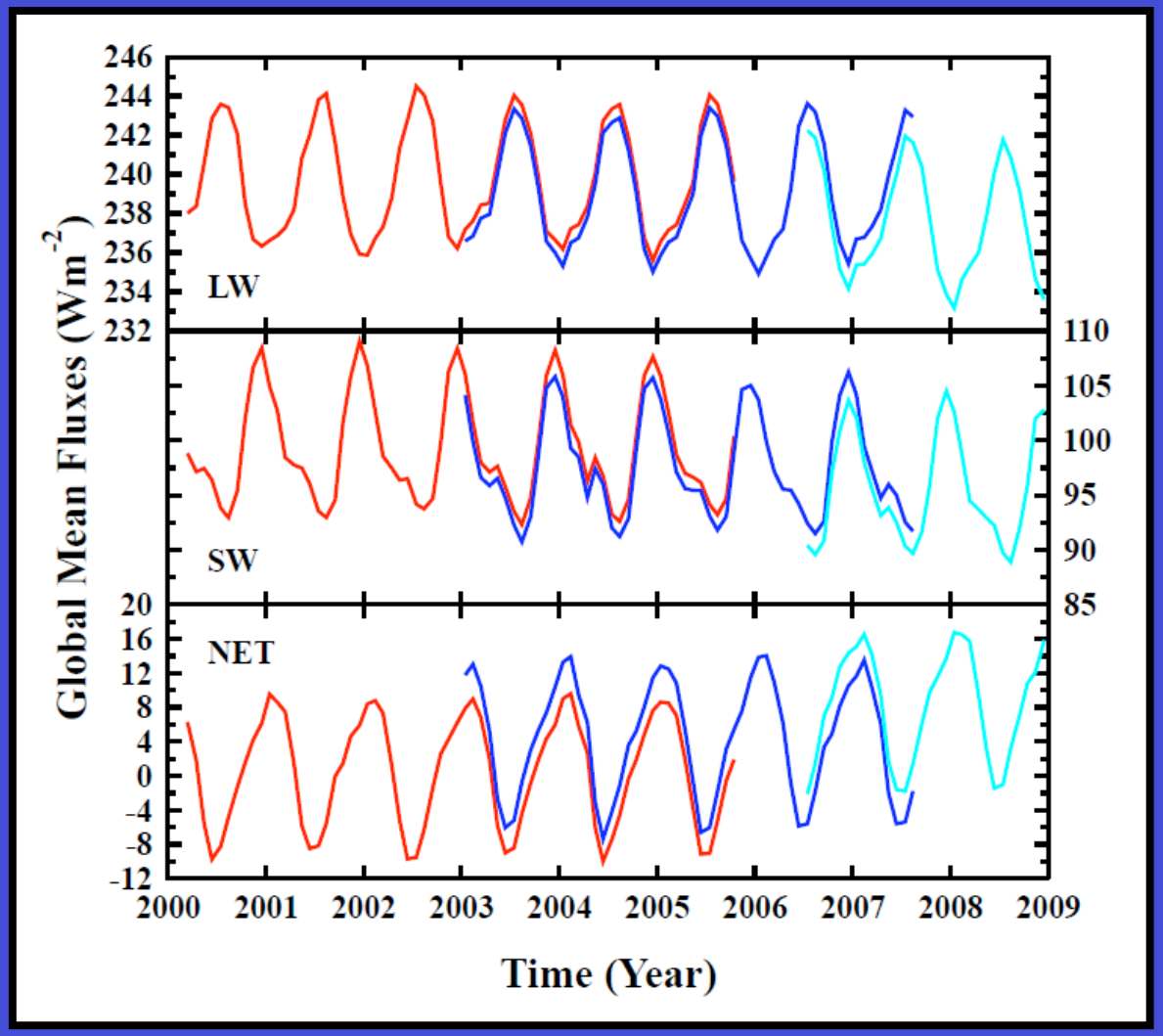
FLASHFlux
Terra+Aqua
7/2006 to 12/2008

(Overlap: 1/2003 to 10/2005) (Overlap: 7/2006 to 8/2007)

- Use overlap periods to remove mean difference between datasets
- Anchor the entire time series to the absolute values of the EBAF



Global Mean Time Series before Adjustments



Global Mean Differences and Adjustment Factors

ERBE-like minus EBAF (Wm^{-2})

	Mean	Std. Dev.
LW	-0.62	± 0.1
SW	-1.42	± 0.4
Net	3.46	± 0.5

FLASHFlux minus ERBE-like (Wm^{-2})

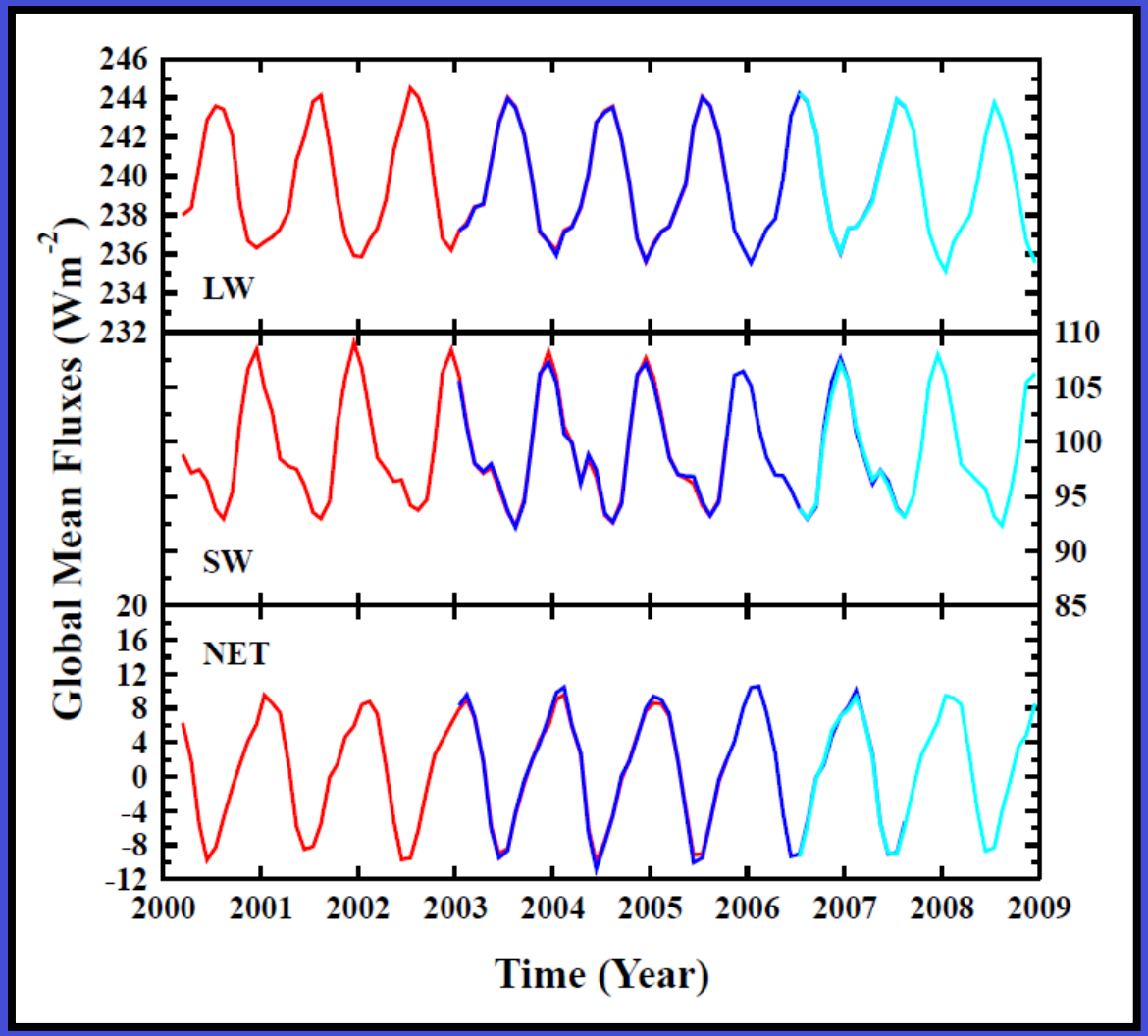
	Mean	Std. Dev.
LW	-1.36	± 0.1
SW	-2.02	± 0.5
Net	3.82	± 0.6

Global Mean Adjustment Factor (Wm^{-2})*

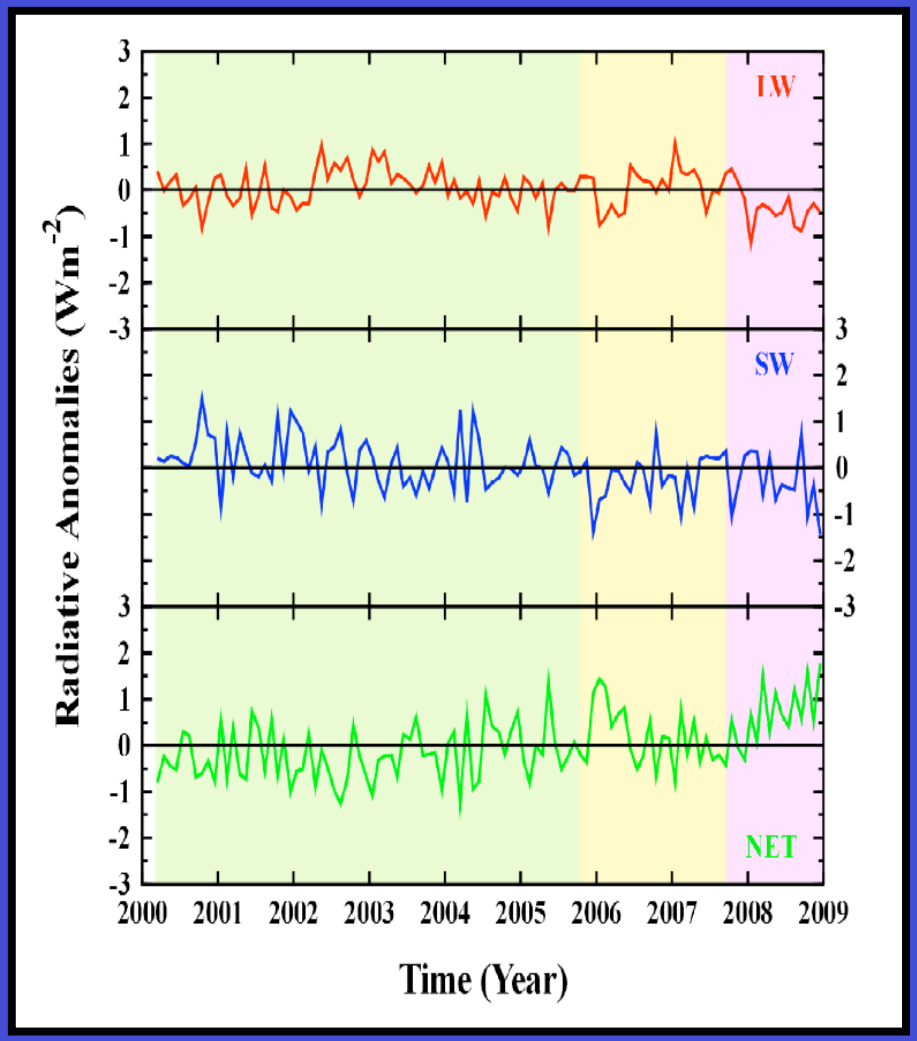
	ERBE-like	FLASHFlux
LW	0.62	1.98
SW	1.42	3.44
Net	-3.46	-7.28

*** Adjustment required to anchor the specific dataset to the EBAF baseline**

Global Mean Time Series after Adjustments



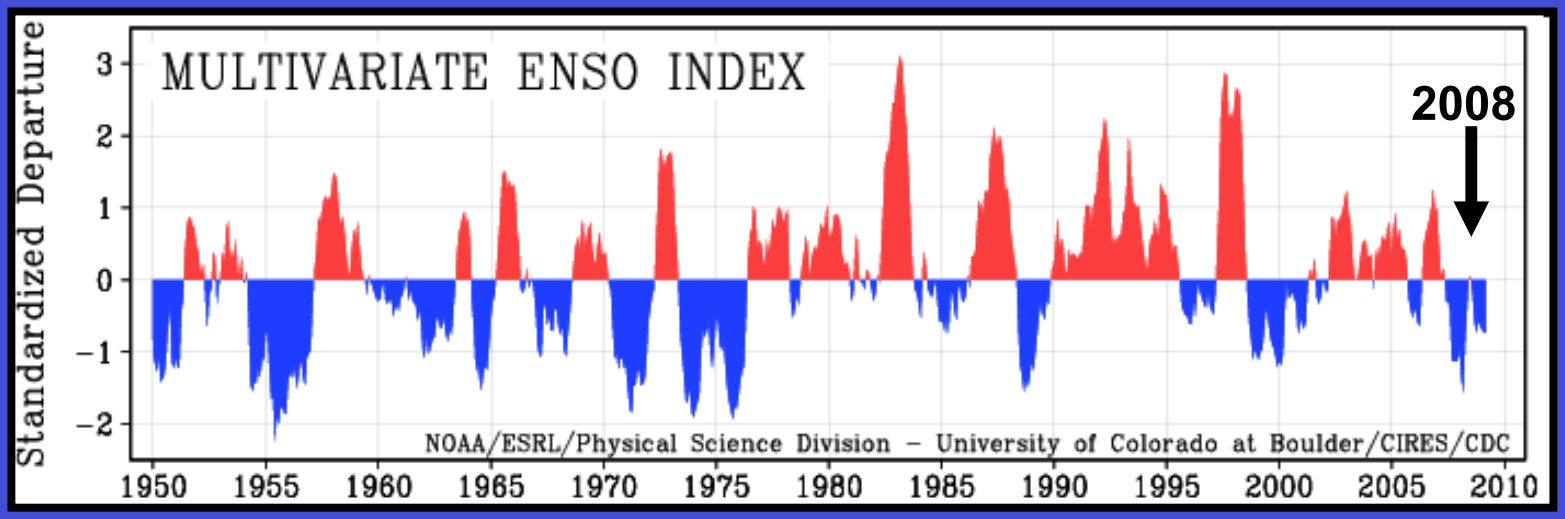
Deseasonalized Anomalies (Preliminary)



	2008 – 2007 change	2008 anomaly	Interannual variability (2-sigma)
LW	-0.75	-0.54	±0.56
SW	-0.14	-0.26	±0.41
Net	+0.89	+0.80	±0.82

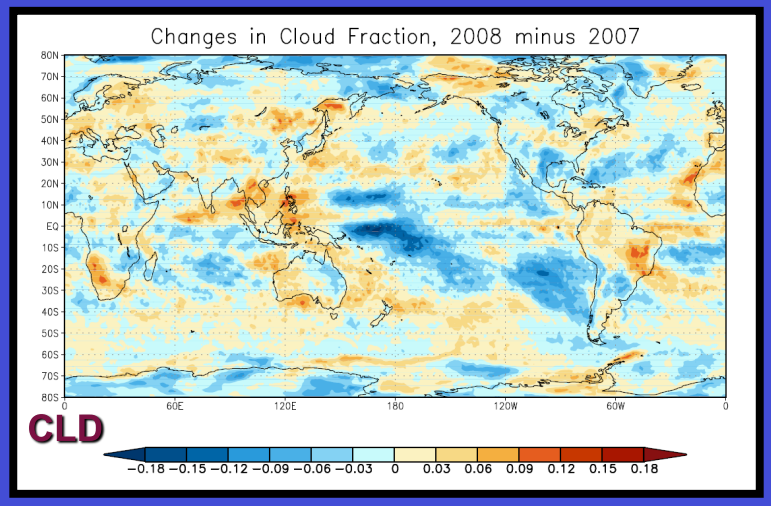
- Large decrease in global mean outgoing longwave radiation in 2008
- Smaller decrease in global mean reflected shortwave in 2008
- Large increase in global mean net flux in 2008
- Majority of net flux increase (~84%) from decrease in longwave
- FLASHFlux calibration issue in 2008 or real climate change signal?

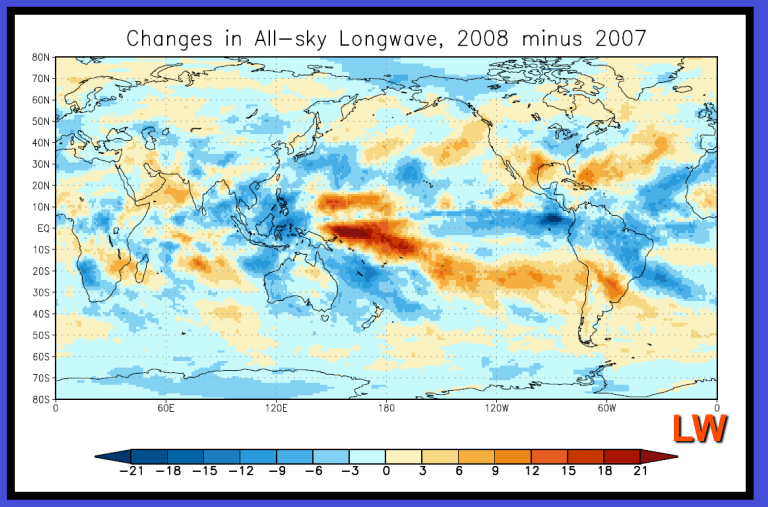
ENSO and 2008 La Nina Event

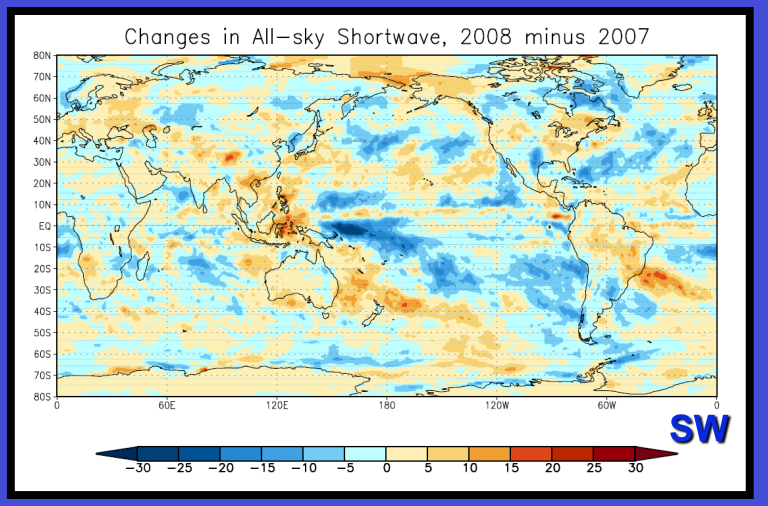


- ENSO cycle was in its negative phase during 2008 (La Nina)
- La Nina can significantly alter the 3-D profiles of temperature and moisture in the atmosphere, which can modify the distribution of clouds in the atmosphere
- Therefore, La Nina can affect the partition of radiative energy in and out of the climate system

Annual Mean Changes in Cloud and Radiation







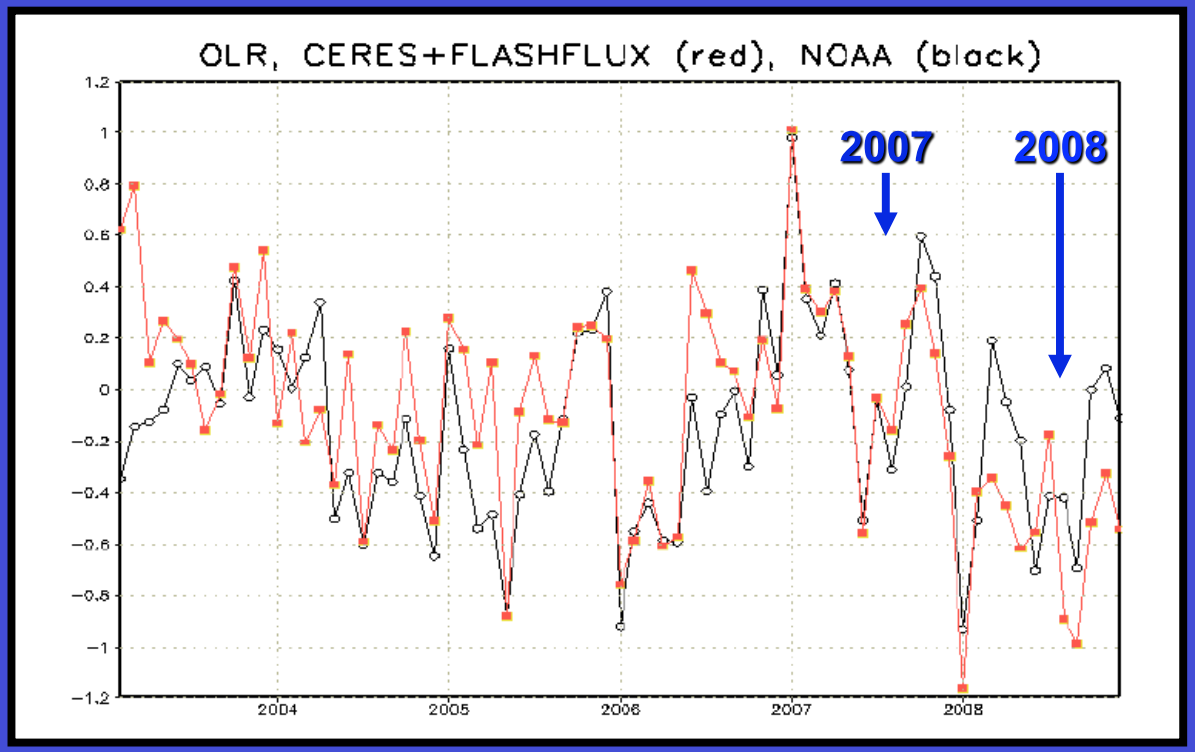
- Changes in regional LW and SW fluxes are consistent with MODIS total cloud fraction changes
- Large LW decreases over the tropical belt
- Smaller, but widespread LW decreases in the polar regions

Changes in Global Mean (2008 minus 2007)

Variable	Absolute Change
LW	-0.75 Wm^{-2}
SW	-0.14 Wm^{-2}
Net	+0.89 Wm^{-2}
$T_{surface}$	~ -0.1 K
T_{low_trop}	~ -0.25 K
CWV	Decrease
Cloud Amount	~ -0.3 %
Ocean Heat	up or down ??

- The increase in global net radiation in 2008 seems to contradict the global temperature cooling during this period
- However, the extra net radiation may have been stored in the ocean

OLR: NOAA AVHRR Vs CERES/FLASHFlux



CERES/FLASHFlux

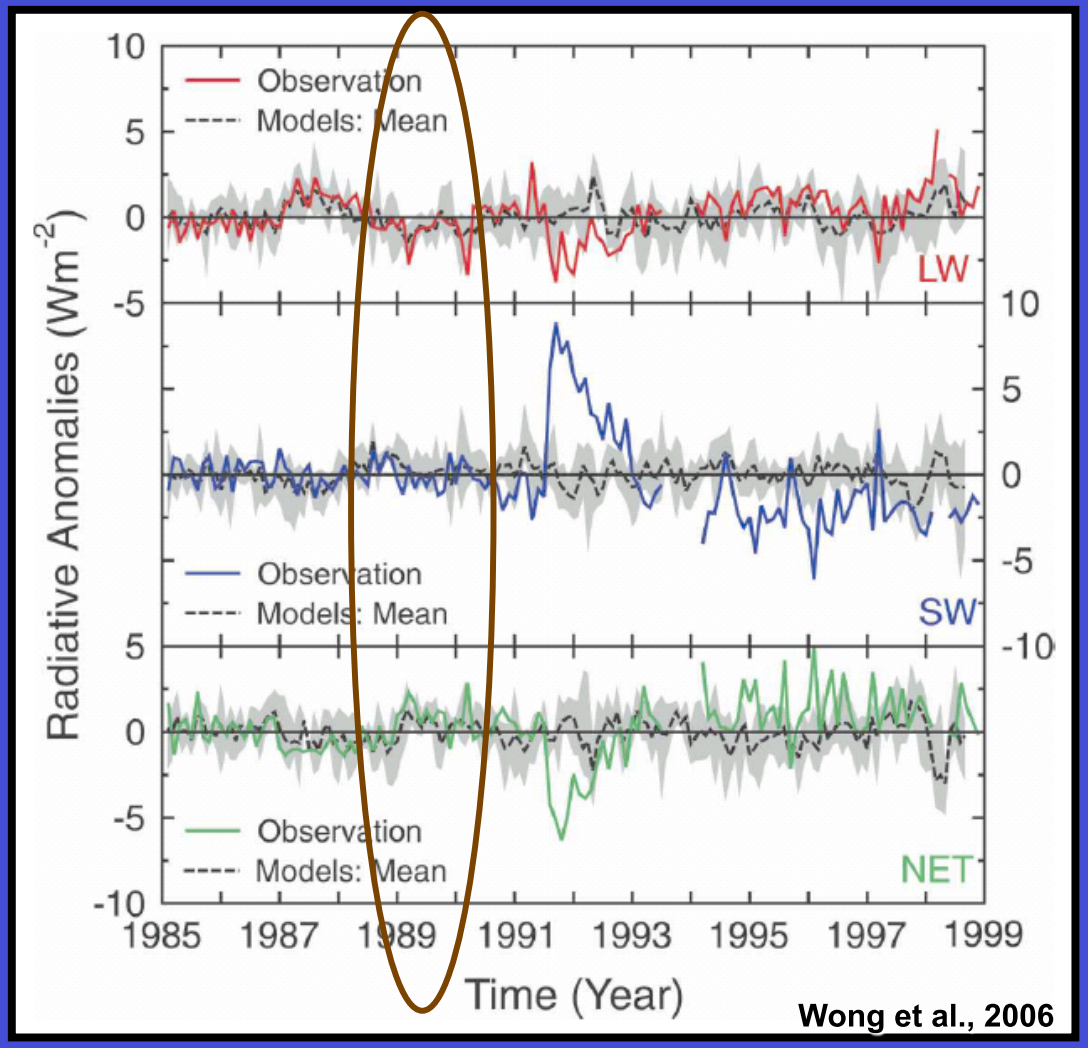
$\Delta LW \sim -0.75\ Wm^{-2}$

NOAA AVHRR

$\Delta LW \sim -0.49\ Wm^{-2}$

- Both NOAA AVHRR and CERES/FLASHFlux indicate a drop in global mean OLR during 2008
- CERES/FLASHFlux saw a larger drop; possible FLASHFlux calibration issue and/or changes in upper tropospheric humidity

1989 La Nina Event



- ERBE/ERBS saw a large drop in LW, a smaller drop SW, and a large rise in Net radiation (20N to 20S) during the 1989 La Nina Event
- The behavior of TOA radiation budget during the 2008 La Nina event is consistent with those of the 1989 La Nina event

Summary

- The first 9 years of CERES record is relatively quiet when compared to the ERBS record.
- CERES/FLASHFlux merged time series shows large changes in 2008 global mean radiation budget during the La Nina event.
  - ΔLW ~ -0.75 Wm^{-2}, ΔSW ~ -0.14 Wm^{-2}, ΔNet ~ +0.89 Wm^{-2}
- The increase in net radiation into the earth system (84% from LW) seems to contradict the global temperature cooling during this period.
- However, the extra net energy may have been used to heat the ocean (waiting for 2008 ocean heat storage data).
- NOAA AVHRR shows a smaller drop in OLR in 2008. Differences in OLR may due to the constant CERES calibration coefficients used in the FLASHFlux data and/or changes in in UTH.
- Additional information (i.e., updated CERES calibration coefficients, AIRS OLR, UTH, as well as ocean heat storage data) will be needed to completely resolve this issue.